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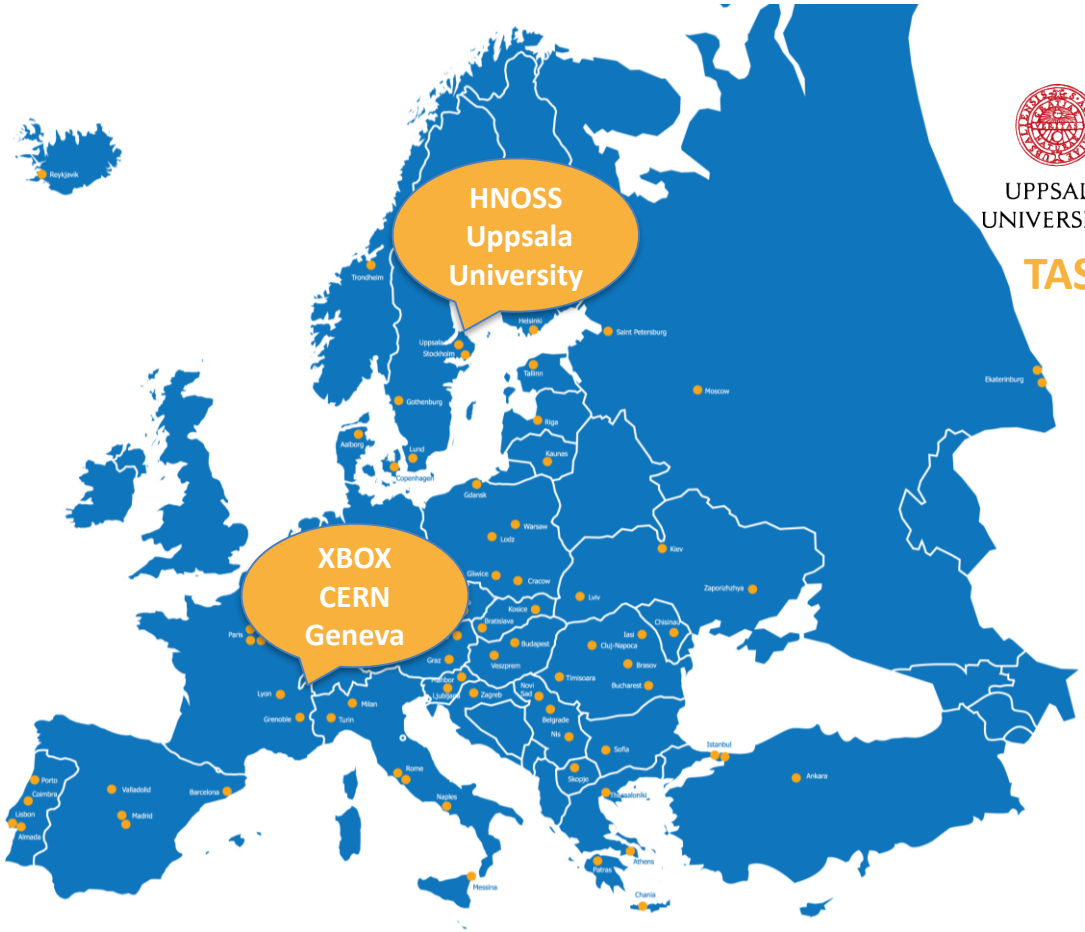
Testing of Advanced RF Structures
TNA WP12 RF Test Stands

1st Annual Meeting, Riga, 22-25 May 2018

Roger Ruber (Uppsala University)
Walter Wuensch (CERN)

WP12 RF Testing Facilities



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FREIA

TASK 12.1 HNOSS

CERN

TASK 12.2 XBOX

The TNA within WP12 groups **TWO** facilities devoted to testing of superconducting RF cavities and normal conducting RF cavities.

ARIES

WP12 User Projects

Two user projects received and approved by the USP

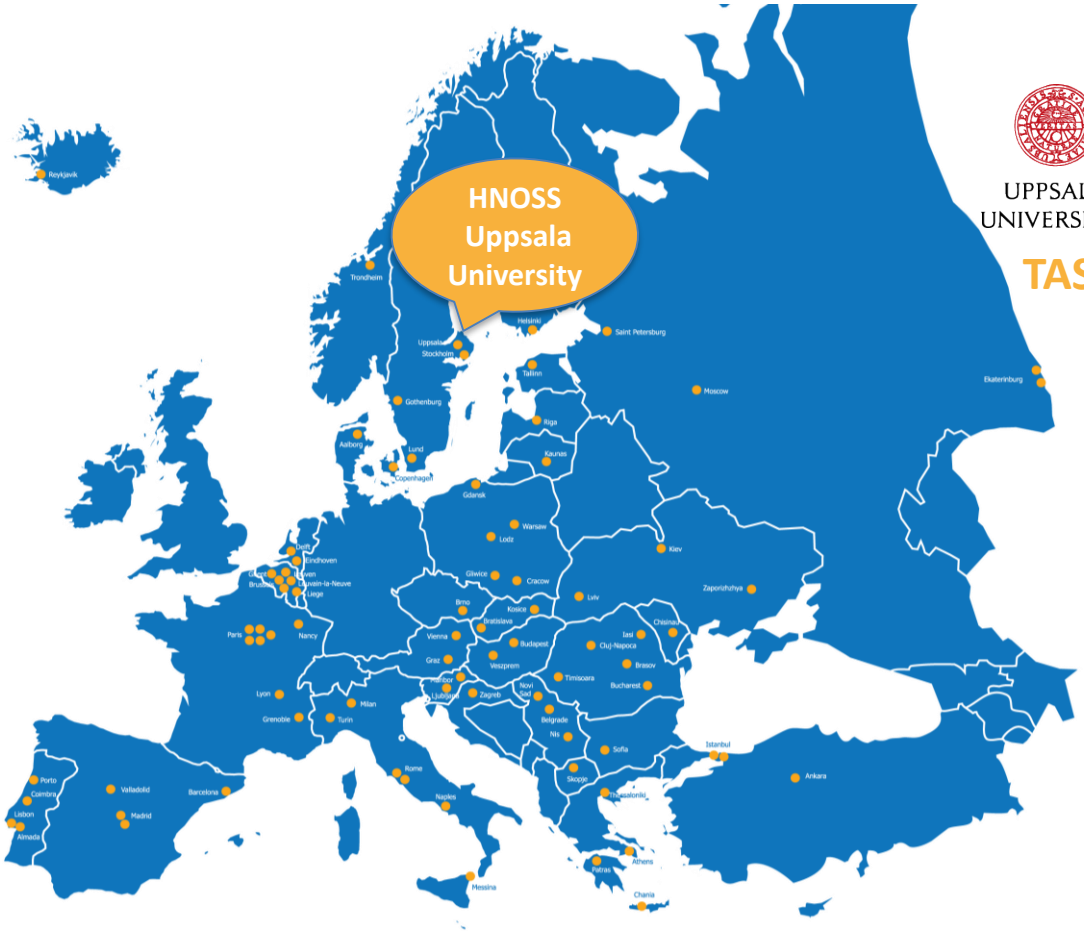
- Project 12-01
  - Title: ESS High-beta Elliptical Cavity
  - Duration: 12 months
  - User group leader: Franck Peauger (CEA, France)
  - Facility: UU-FREIA
  - Access: 720 (of 2880) units, 1st (of 4) projects

- Project 12-02
  - Title: Dark and breakdown current studies
  - Duration: 2017-2018
  - User group leader: Marek Jacewcz (UU, Sweden)
  - Facility: CERN-XBOX
  - Access: 1500 (of 6000) units, 1st (of 4) projects

WP12 User Selection Panel (USP)

- Common USP
  - selection based on scientific quality and feasibility,
  - 3 independent experts:
    - Kenneth Österberg (Helsinki Univ., Finland)
    - Jiaru Shi (Tsinghua Univ., China)
    - Slava Yakovlev (Fermilab, US)
  - facility coordinators:
    - Roger Ruber (HNOSS, UU)
    - Walter Wuensch (XBox, CERN)
- User requests
  - contact: e-mail to WP coordinator: ruber@physics.uu.se
- Target is to respond to a request within ~2 months

WP12 RF Testing Facilities



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FREIA

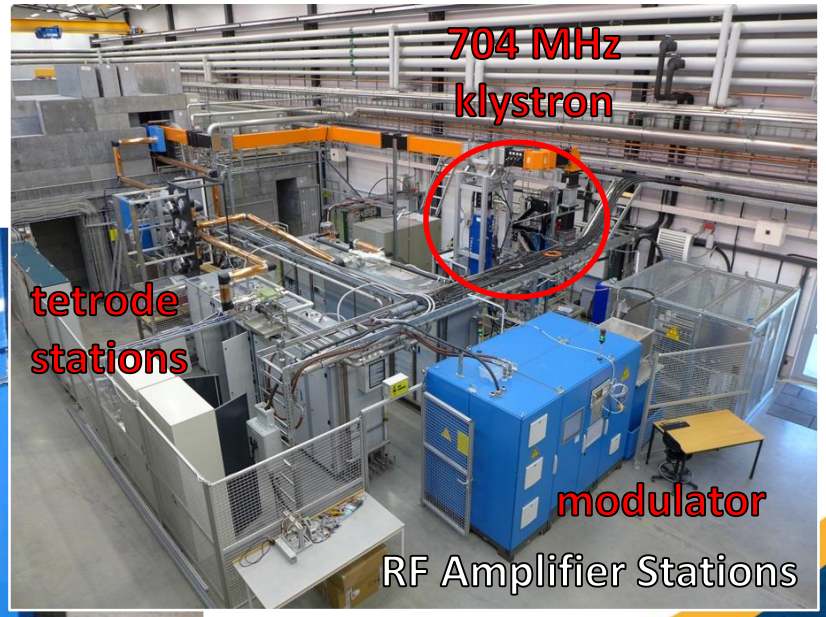
TASK 12.1 HNOSS

The **HNOSS** facility at the FREIA Laboratory, Uppsala University, Sweden, is available for testing of superconducting RF cavities with integrated helium tank.

ARIES

WP12.1 The Hnoss TNA

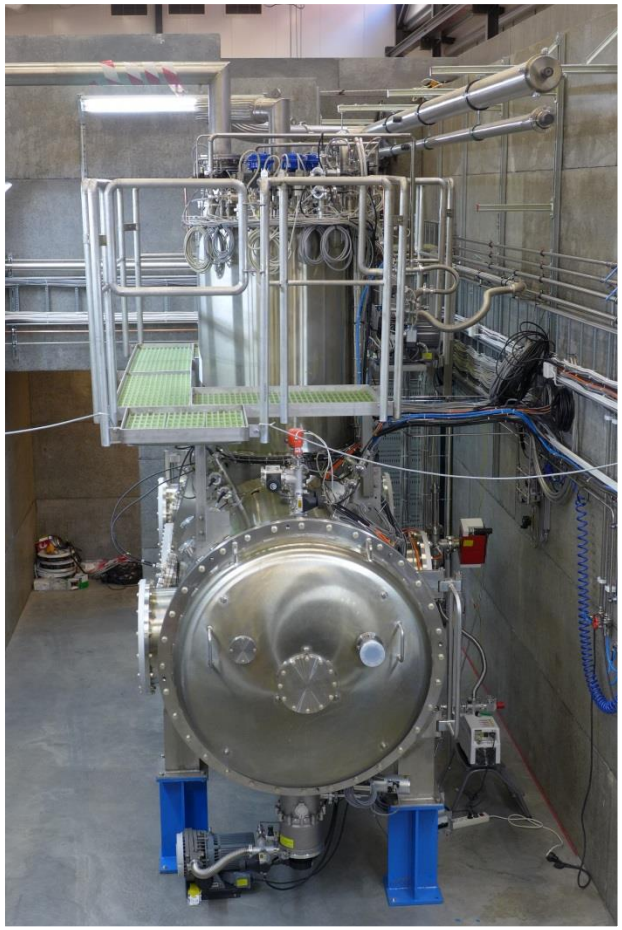
- Located at Uppsala University, the HNOSS test stand is used to test and characterize superconducting cavities
- There are 4 RF high power RF sources available, two at 352 MHz at 400 kW_{pulsed}, one at either 352 or 400 MHz at 50 kW_{CW}, and one at 704 MHz at 1.5 MW_{pulsed}, extensive instrumentation and support infrastructure (radiation shielding, SHe & water cooling, vacuum, etc).
- The user community spans
  - High-power proton accelerators
  - High-power electron accelerators



WP12.1 The Hnoss TNA - Facility Overview

HNOSS = Horizontal Nugget for Operation of Superconducting Systems
Gersemi & Hnoss are the two daughters of the goddess Freia

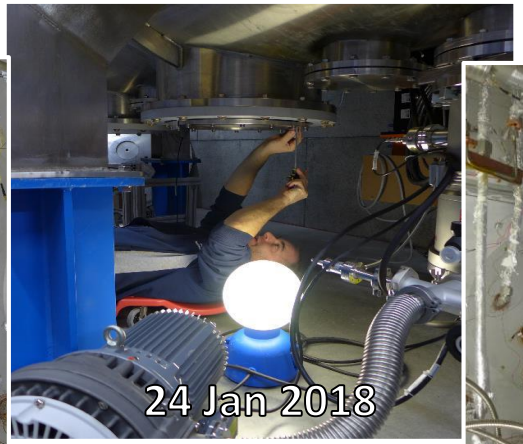
- Horizontal cryostat for test and characterization of superconducting cavities:
  - up to two cavities simultaneously,
  - each equipped with helium tank,
  - option: fundamental power coupler and (cold) tuning system
  - supercritical helium and LN2 cooling
- Low or High power RF testing
  - driven by self-excited loop or generator
- Operation in the range 1.8 to 4.5K,
  - sub-atmospheric pumps 90 W at 1.8 K

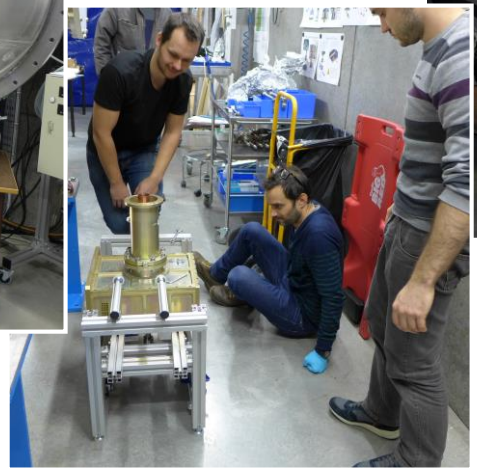


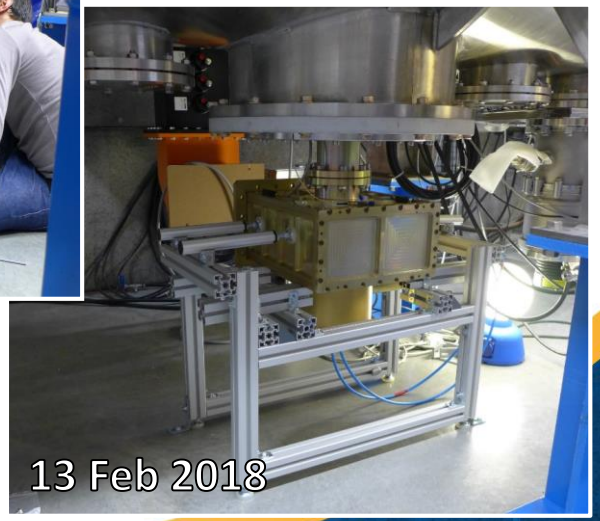
WP12.1 The Hnoss TNA - First TNA

- Test and characterization of a high-beta elliptical cavity with fundamental power coupler and cold tuning system, for CEA Saclay and the ESS,
- Has been installed and commissioning is under way,
  - start-up delayed due to technical issues with the high power klystron and RF-load
- Objective is the validation and characterization of the complete cavity package

WP12.1 The Hnoss TNA - First TNA



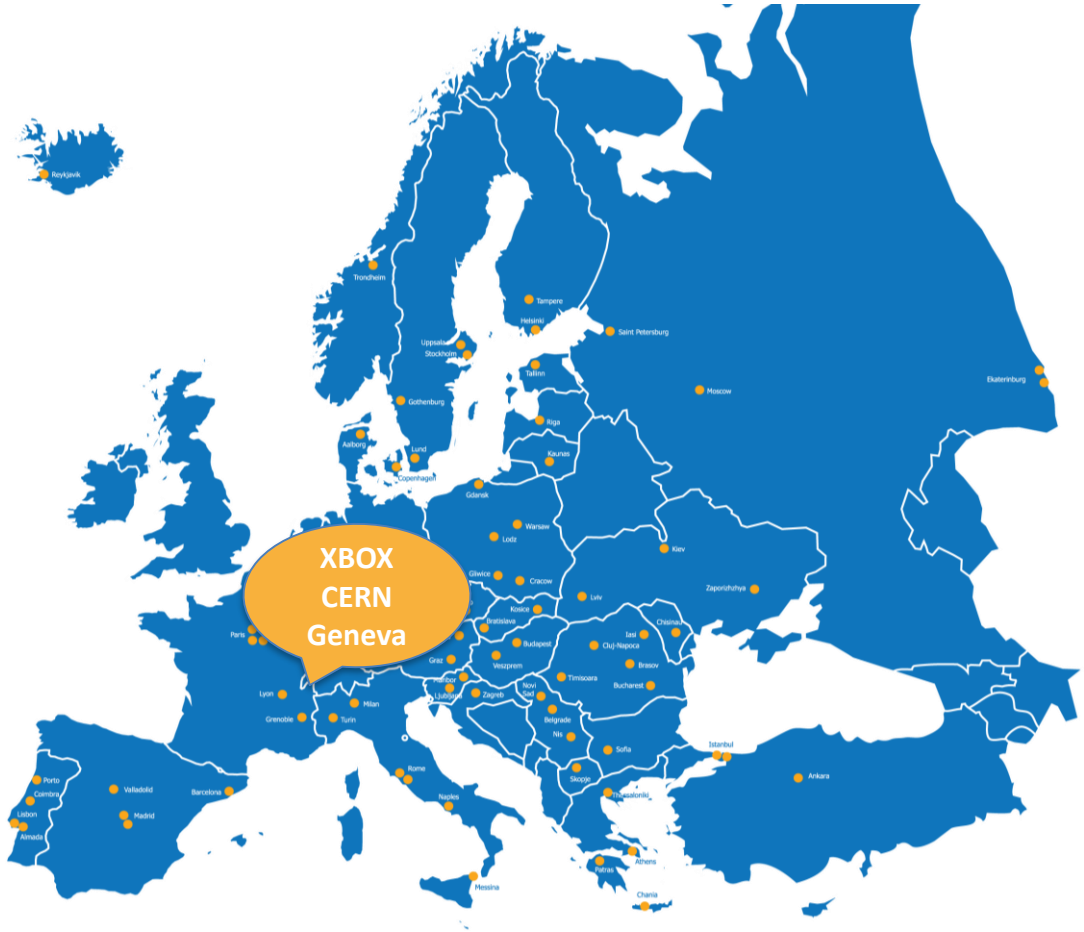




WP12.1 The Hnoss TNA - First TNA

- Preparation of the high power RF source
- on loan from ESS

WP12 RF Testing Facilities



CERN

TASK 12.2 XBOX

The **XBox** facility at CERN, Switzerland, is available for testing of normal conducting RF cavities/structures at X-band frequency.

ARIES

WP12.2 The Xbox TNA

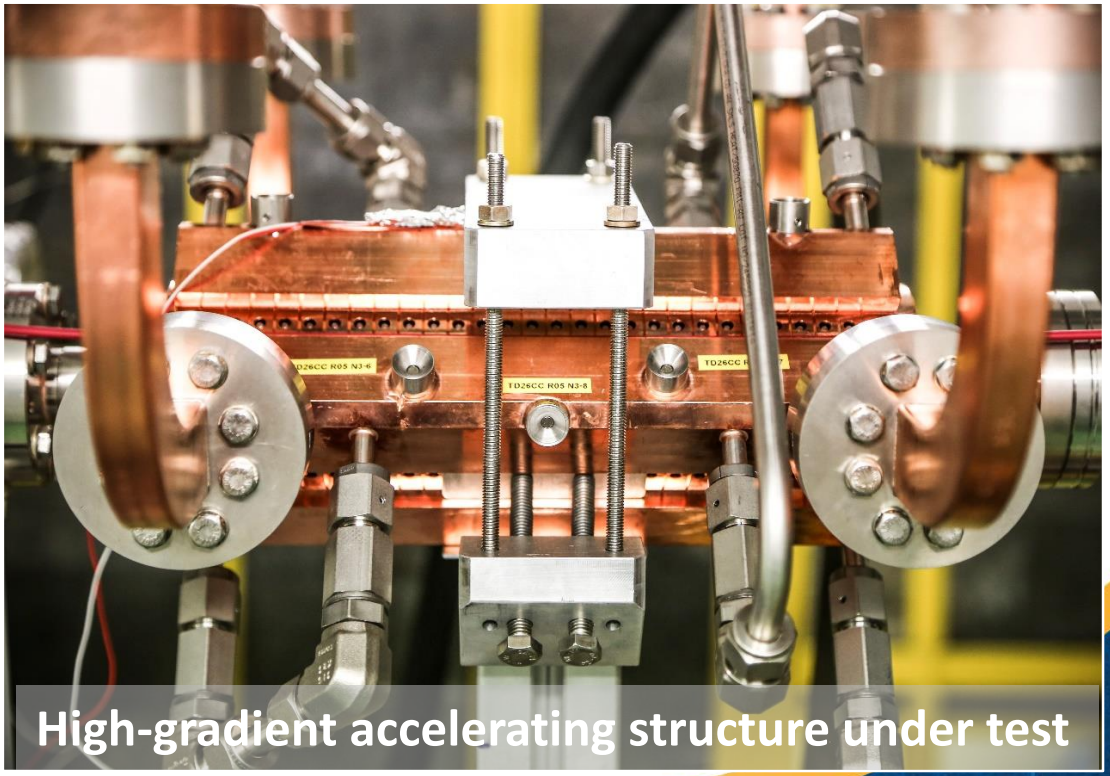
- Located at CERN, and built up by the CLIC collaboration, the Xbox test stands are used to carry out high-gradient accelerator technology development and research into the multiple process which occur at high surface fields.
- There are four independent klystron-based test stands with peak powers in the range of 50-150 MW, extensive instrumentation and support infrastructure (radiation shielding, water cooling, vacuum, etc).
- The user community spans:
  - High-performance normal-conducting electron linacs
  - High-gradient proton linac applications such as medical
  - High-power device users such as satellite communication
  - Material science and plasma physics groups who study high-field dynamics

Xbox-3 klystron-modulator rf power unit

WP12.2 The Xbox TNA

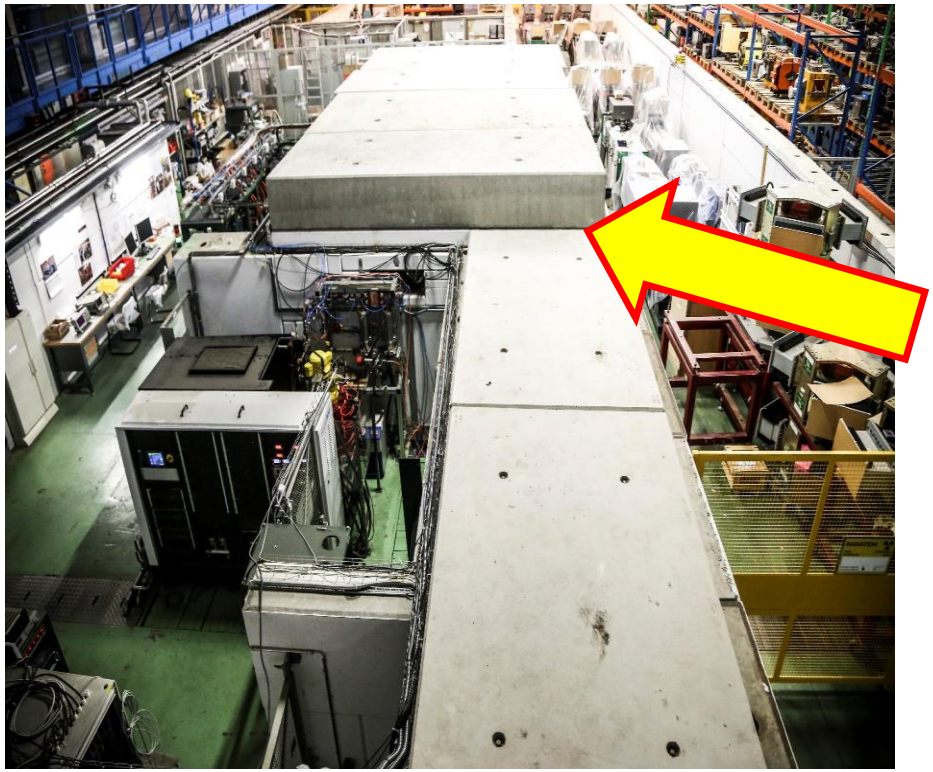
Typical experiments include:

- High-gradient test accelerating structures for ultimate performance, rf design, conditioning, effect of fabrication and preparation, operational control, long-term operation
- High-power test waveguide components including pulse compressors, windows, combiners, mode converters
- High-field studies including breakdown limits and dynamics, field emission, dark current capture, radiation, dynamic vacuum



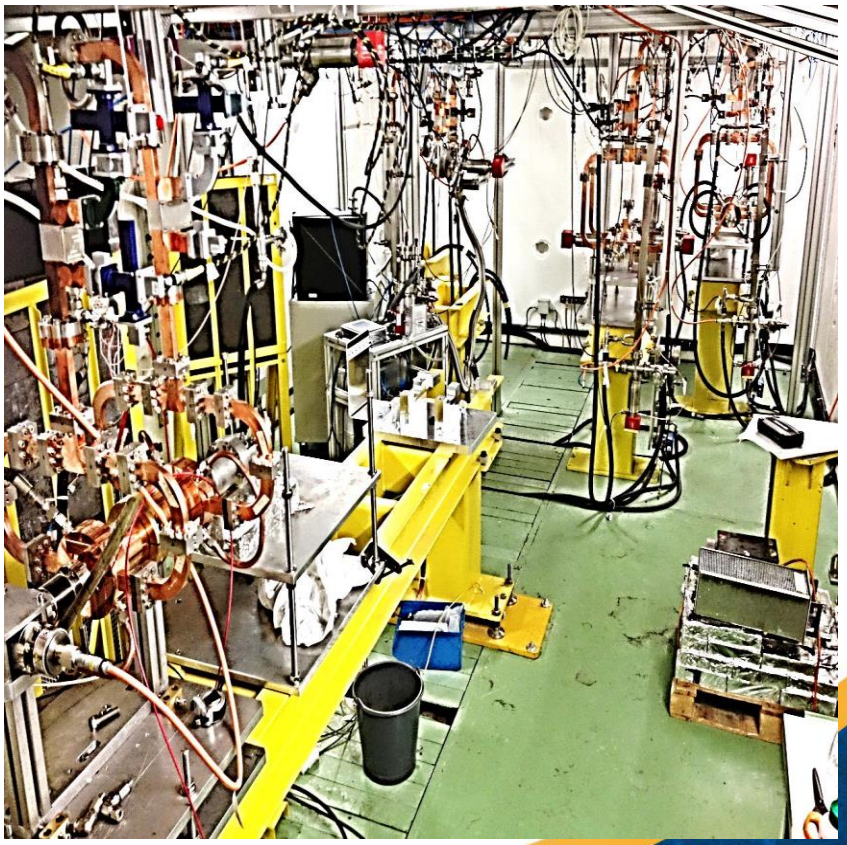
High-gradient accelerating structure under test

WP12.2 The Xbox TNA - Facility Overview



XBox2 power unit outside of experimental bunker

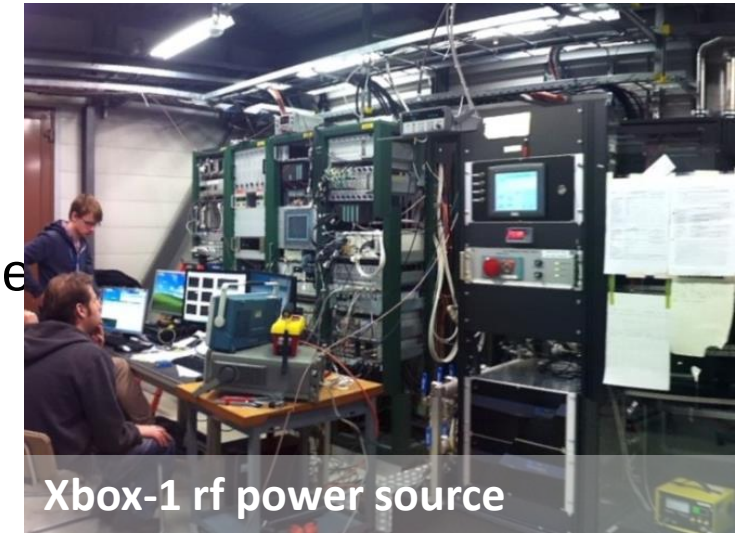
Inside experimental bunker



WP12.2 The Xbox TNA - Facility Overview

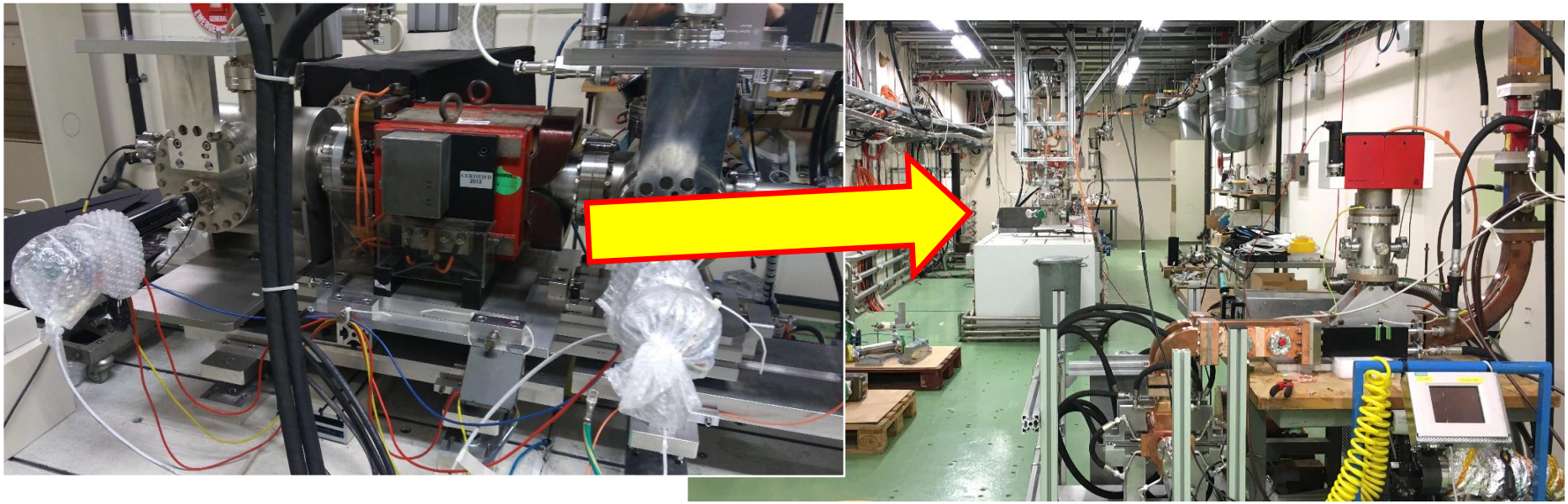
Characteristics:

- 50-150 MW peak power from modulator-klystron-pulse compressor units
- All sub-systems: vacuum, water cooling, e
- Extensive instrumentation
- Full computer control
- 24/7 operation, typical experiments take from days to months.
- We have relatively many access units per user project.
- A generic user project consists of on-site installation, commissioning and initial data taking followed by remote access during extended running


Xbox-1 rf power source


Xbox-1 experimental bunker

WP12.2 The Xbox TNA - First TNA



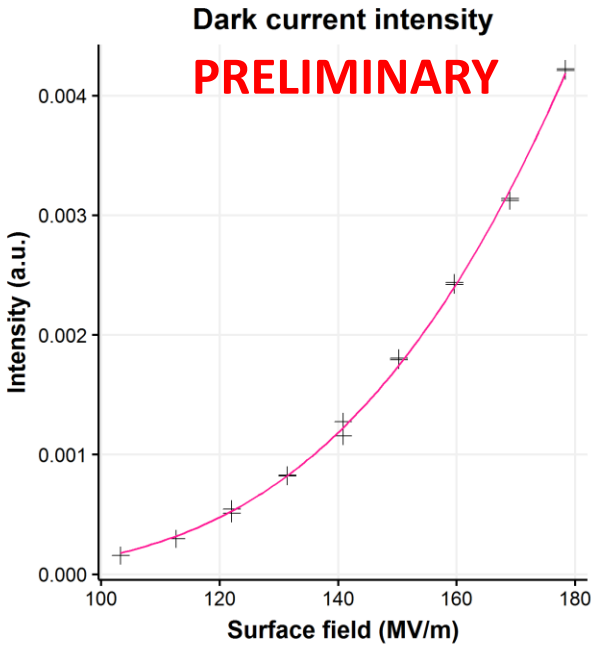
- The first TNA “Dark and breakdown currents studies with the Uppsala X-band Spectrometer” has been installed, commissioned and remote data taking is underway.

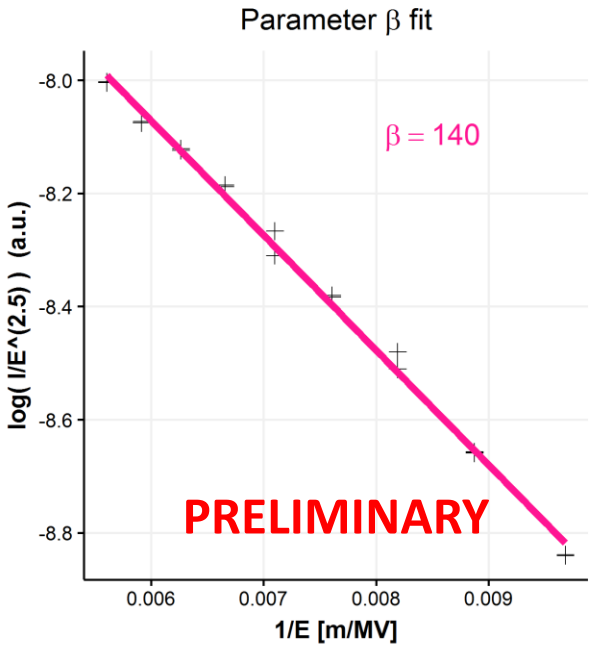
- Objective is to study high-field effects using a spectrometer magnet, collimator, screens and fast cameras.

WP12.2 The Xbox TNA - First TNA

- Dark current can give information about changes inside the structure during conditioning:
  - use the spectrometer to look at the changes, both spatially on the screen and by measuring the energy spectrum
- Enhancement factor β accounts for the increase in a local (microscopic) field value E_{local} from the ideal surface field E
  - $E_{local} = \beta * E$

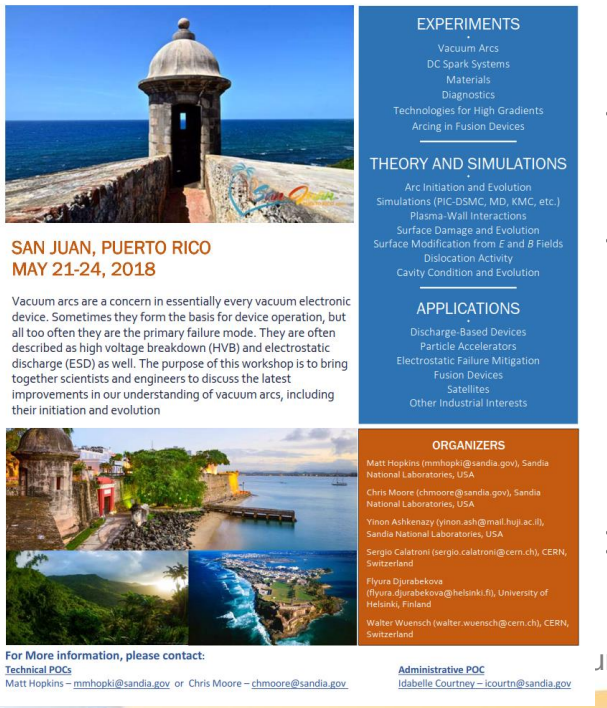
- **Good agreement with underlying theory of field emission**





WP12.2 The Xbox TNA - Outlook

- The first TNA User Project is underway, will continue during the coming months
- Discussions are underway with various groups for future User Projects. We hope to see the next proposal in the coming months.
- Four user Projects are promised in the proposal. A typical User Project is quite complex, often requires some form of approval at the level of the proposing institutes, so lead times are long. But we should be OK.
- Next advertising pushes will be dedicated posters at two international workshops:



https://indico.cern.ch/event/680402/

https://indico.cern.ch/event/675785/